them. The distributed feedback grating was clearly specified as being incorporated with the epitaxial structure. It was also specified as formed and positioned to act upon the light generated in the active region to produce lasing action and emission of light from at least one of the upper and lower faces of the semiconductor laser. It is also noted that no objection to the language of the claims was made in the first Office Action on the merits of this application, dated November 20, 2001.

By the amendment above, Claims 13-26 have been cancelled without prejudice to introduction of such claims in a continuation application.

The remaining claims, Claims 27-43, were rejected under 35 U.S.C. § 103(a) as unpatentable over the U.S. patent to Kurobe, et al., 5,432,812, in view of the patent to Kinoshita, 4,958,357. For the reasons discussed below, what is shown in Kurobe, et al. is fundamentally different from what is claimed in Claim 27 and the claims dependent thereon, and Kurobe, et al. cannot be modified by combining it with Kinoshita because of these fundamental differences.

The Kurobe, et al. patent describes a vertical-cavity surface-emitting laser (VCSEL). In contrast, the present invention is a surface-emitting distributed feedback laser

NOT CLAIMED

with a horizontal cavity, and thus it is not a vertical cavity laser. The vertical cavity in Kurobe, et al. is defined by the vertically spaced distributed Bragg reflectors (DBRs) 210 and 230. No surface-emitting grating is disclosed by Kurobe, et al. The gratings shown in Kurobe, et al. are for confinement of the light to a very small cavity of a size on the order of the wavelength of light in the medium, for purposes described in Column 11, lines 24-28 of Kurobe, et al. In addition, the grating 275 of Kurobe, et al. is a 1st-order grating (as seen from

Figs. 14 and 15), which cannot radiate light in a direction perpendicular to the upper and lower faces of the chip; that is, it cannot diffract light upwards to cause any kind of surface emission. The purpose of the grating of Kurobe, et al. is further seen with respect to Kurobe Figs. 16 and 17 where a periodic variation of the dielectric constant is introduced solely for the purpose of confining light to a small disk-like cavity (A0 in Fig. 17).

Thus, combining Kinoshita and Kurobe, et al. is not only not obvious, but does not result in applicants' claimed structure. In Kinoshita, a distributed feedback (DFB) grating provides both feedback as well as surface emission of the light generated in the active region, while in Kurobe, et al., the two gratings (acting as distributed Bragg reflector gratings) confine light to a flat region (i.e., a region without a grating) from which the light is surface emitted due to lasing in a vertical cavity defined by multi-layer sections (vertically spaced DBRs) serving as mirrors. Note that the multi-layer DBRs of Kurobe, et al. do not meet the requirement of Claim 27, subparagraph (c) of distributed Bragg reflector gratings. The multi-layer DBR reflectors of Kurobe, et al. are not gratings and are different structures providing vertical confinement and feedback of light for a VCSEL, rather than the DBR reflector gratings of applicants' invention, which provide feedback in the longitudinal (or horizontal) direction (in addition to the feedback provided by the DFB section). Incorporating the vertically spaced multi-layer reflectors of Kurobe, et al. into the Kinoshita structure or vice versa would be useless.

Furthermore, the flat region in the Kurobe, et al. grating is not a grating phase shift, but an in-plane cavity defined by 1st-order DBR grating reflectors which provide horizontal confinement of light and thus do not serve as a distributed feedback grating. See,

e.g., Col. 11, lines 22 of Kurobe, et al.: "Optical component horizontally progressing in the corrugated section is reflected back toward the central region by the both-side DBRs to minimize the work-less component along the horizontal direction. This can function to further improve the coupling ratio β of spontaneous emission, so that the threshold current level can be lowered."

With regard to the Kinoshita patent 4,958,357, applicants submit herewith a copy of a later paper by Kinoshita (IEEE J. of Quantum Electronics, Vol. 26, No. 3, March, 1990, pp. 407-412), which further describes the grating-coupled surface-emitting laser of the Kinoshita patent. As explained in the first column of the Kinoshita paper, there are three types of surface-emitting lasers: the vertical-cavity-type, the grating-coupled-type, and the 45°-deflecting mirror type. The Kinoshita device is a grating-coupled-type, not a vertical-cavity-type as in the Kurobe, et al. patent. As noted in the first column on page 408 of the Kinoshita paper, Kinoshita assumes in his calculations that the radiation power is very small compared with the guided-mode power. In contrast, the present invention is capable of achieving high radiation powers.

The foregoing amendment to Claim 27 clarifies the structure in the claim to specify the distributed Bragg reflector gratings being adjacent to each of the longitudinal ends of the distributed feedback grating to reflect light back longitudinally to the distributed feedback grating. As noted above, the claim language as originally submitted specified distributed Bragg reflector <u>gratings</u> adjacent the distributed feedback grating, which distinguishes over vertical-cavity-type structures as shown in Kurobe, et al. Further amendments have been made in the language of Claim 27 for clarity, but no new features are

specified in addition to those in the claim as filed. As discussed in the present application on page 5, lines 7 *et seq.*, the use of the distributed Bragg reflector gratings adjacent to the ends of the distributed feedback grating allows both high efficiency and a high degree of guided-field uniformity. The achievement of these results is not disclosed or suggested in Kinoshita.

For the foregoing reasons, it is submitted that Claim 27 and Claims 28-43 dependent thereon, which add further preferred features to the structure of Claim 27, are patentably distinguishable from the cited references, and favorable action passing the application to allowance is respectfully requested.

Respectfully Submitted,

Harry C. Engstrom, Reg. No. 26,876
Attorney for Applicants
Foley & Lardner
150 East Gilman Street
Post Office Box 1497
Madison, Wisconsin 53701-1497
(608) 258-4207

COPY OF CLAIMS SHOWING AMENDMENTS

27. (Amended) A surface emitting semiconductor laser comprising:

(a) a semiconductor structure including a substrate[,] and an epitaxial structure on the substrate, the epitaxial structure including a layer with an active region at which light emission occurs, an upper cladding layer above the active region layer and a lower cladding layer below the active region layer [upper and lower cladding layers surrounding] to surround the active region layer, the semiconductor structure having an upper face, a [and] lower face[s], and edge faces that terminate the semiconductor structure longitudinally, and electrodes at the upper and lower faces by which voltage can be applied across the epitaxial structure and the substrate;

(b) a distributed feedback grating incorporated with the epitaxial structure and terminating longitudinally at ends thereof, comprising periodically alternating grating elements to provide optical feedback as a second order grating for a selected effective wavelength of light generation from the active region, the grating having a spacing between adjacent grating elements at a position intermediate the [edge faces] ends of the grating that corresponds to a selected phase shift in the grating, the grating formed and positioned to act upon the light generated in the active region to produce lasing action and emission of light from at least one of the upper and lower faces [of the semiconductor laser]; and

(c) [passive] distributed Bragg reflector gratings incorporated with the epitaxial structure and adjacent to each of the longitudinal ends of the distributed feedback grating to reflect light back longitudinally to the distributed feedback grating.

32. (Amended) The semiconductor laser of Claim 27 wherein the electrodes are formed on the upper and lower faces of the semiconductor laser and [with] the upper electrode is formed on a cap layer to define an active stripe width over the active region layer at which light emission occurs.